DATA COMPRESSION/EXPANSION ON A PLURALITY OF DIGITAL INFORMATION SIGNALS

BACKGROUND OF THE INVENTION

The invention relates to a data compression apparatus for data compressing at least a first and a second digital information signal, each of the at least two digital information signals comprising subsequent samples, the apparatus comprising:

- means for receiving the first and second digital information signal,
- signal combination means for combining the first and second digital information signal so as to obtain a composite information signal,
- data compression means for data compressing the composite information signal so as to obtain a data compressed composite information signal,
- output means for supplying the data compressed composite information signal, to a data expansion apparatus for data expanding a data compressed composite information signal obtained from at least a first and a second digital information signal, the apparatus comprising
- input means for receiving the data compressed composite information signal,
- data expansion means for data expanding the data compressed composite information signal so as to obtain a data expanded composite information signal,
- retrieval means for retrieving a replica of the first and second digital information signal from the data expanded composite information signal,
- output means for supplying the replicas of at least the first and second digital information signals, to a transmitter comprising the data compression apparatus, to a receiver comprising the data expansion apparatus, to a method for data compression, to a method for data expansion and to a record carrier.

Data compressing a stereo audio signal is well known in the art. Reference is made in this respect to EP-A 402,973, document D1 in the list of related documents. The document describes a subband coder, in which each of the left and right hand signal components of the stereo audio signal is A/D converted with a specific sampling frequency, such as 44.1 kHz, and the resulting samples in de form of eg. 24 bits wide words of the audio signal, are supplied to a subband splitter filter. The subband splitter filter splits the audio signal component into a plurality of relatively narrow band subband signals. Using a psycho acoustic model, a masked threshold is derived and blocks of samples of the subband signals are subsequently quantised with a specific number of bits per sample for each block of the subband signals, in response to said masked threshold, resulting in a significant data compression of the audio signal to be transmitted. The data compression carried out is based on 'throwing away' those components in the audio signal that are inaudible and is thus a lossy compression method.

In an intensity stereo mode, a further data reduction can be obtained by combining, in the same subband, samples of the subband signals of the left and right hand signal components of the stereo audio signal, by adding them so as to obtain samples of a composite subband signal and carrying out a data compression on the composite subband signal.

The data compression described in document D1 is a rather intelligent data compression method and requires a substantial number of gates or instructions, when realized in hard or software respectively, so that it is expensive. Moreover, the subsequent expansion apparatus also requires a substantial number of gates or instructions, when realized in hardware or software respectively.

SUMMARY OF THE INVENTION

The invention aims at providing a data processing apparatus for data compressing at least a first and a second digital information signal such that the information signals can be data compressed in a more simple way, with a simpler data compressor, such as a lossless coder. Further, the corresponding expander apparatus can also be more simple and less expensive.

The data compression apparatus in accordance with the invention comprises merging means for merging samples of the first and second digital information signal after each other into one datastream so as to obtain said composite information signal, said data compression means having a control input for receiving a control signal, the data compression means being adapted to data compress the composite information signal in response to said control signal, control signal generation means being available, for generating said control signal, said control signal generation means having an input for receiving said composite information signal and being adapted to generate said control signal in response to said composite information signal.

Preferred embodiments of the data compression apparatus, a corresponding data expansion apparatus, a transmitter comprising the data compression apparatus, a receiver comprising the data expansion apparatus and a record carrier, are the subject of the subclaims.

BRIEF DESCRIPTION OF THE DRAWING

These and other aspects of the invention will be apparent from and elucidated further with reference to the embodiments described in the following figure description, in which

FIG. 1 shows an embodiment of the data compression apparatus,

FIG. 2 shows another embodiment of the data compression apparatus,

FIG. 3 shows another embodiment of the merging unit,

FIG. 4 shows the data compression apparatus of FIG. 1 incorporated in a recording apparatus for recording the data compressed composite signal on a record carrier,

FIG. 5 shows the data compression apparatus incorporated in a transmission apparatus for transmitting the data compressed composite signal via a transmission medium,

FIG. 6 shows a further embodiment of the recording apparatus, further provided with an error correction encoder and a channel encoder,

FIG. 7 shows an embodiment of a data expansion apparatus for data expanding the data compressed composite signal into replicas of the original information signals,

FIG. 8 shows another embodiment of the data expansion apparatus,

FIG. 9 shows another embodiment of the retrieval unit,

FIG. 10 shows the data expansion apparatus of FIG. 7 incorporated in a reproducing apparatus for reproducing the data compressed composite signal from a record carrier, and

FIG. 11 shows the data expansion apparatus of FIG. 7 incorporated in a receiving apparatus for receiving the data compressed composite signal from a transmission medium,

FIG. 12 shows a further embodiment of the reproducing apparatus, further provided with a channel decoder and an error correction unit,

DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 shows an embodiment of the data compression apparatus in accordance with the invention, comprising an input terminal 1 for receiving samples $L_0,L_1,L_2, \ldots$ of a first digital information signal and an input terminal 2 for receiving samples $R_0,R_1,R_2, \ldots$ of a second digital information signal. In the present example, the first and second digital information signals are the left and right hand signal components respectively of a stereo audio signal.

The input terminal 1 is coupled to a first input 3 of a merging unit 6. The input terminal 2 is coupled to a second input 4 of the merging unit 6. An output 8 of the merging unit 6 is coupled to an input 10 of a data compression unit 12, which has an output 14 coupled to an output terminal 16. Further, a control signal generation unit 18 is available, having an input coupled to the output 8 of the merging unit 6 and an output coupled to a control signal input 19 of the data compression unit 12.

The apparatus of FIG. 1 functions in the following way. The samples of the left and right hand signal components of the stereo audio signal are supplied to the merging unit 6, which merges the samples in such a way into one composite datastream that the samples in the composite signal are arranged in the following sequence:

$$L_0,R_0,L_1,R_1,L_2,R_2,L_3, \ldots$$

The composite signal thus obtained is supplied to the data compression unit 12, which is preferably in the form of a lossless data compression encoder, such as a Huffman type encoder or an arithmetic coder.

Lossless encoders have the advantage that they can data compress an information signal in such a way that, after data expansion by a lossless decoder, the original information signal can be reconstructed in a substantially lossless way. That means that there is substantially no loss of information after compression-expansion. Lossless coders can be in the form of a variable length coder. Variable length coders are well known in the art. Examples of such variable length coders are (the already mentioned) Huffman coders, arithmetic coders and Lempel-Ziv coders. Reference is made in this respect to the publications 'A method for the construction of minimum-redundancy codes' by D. A. Huffman, document D2 in the list of related documents, 'An introduction to arithmetic coding' by G. G. Langdon, document D3 in the list of related documents, and 'A universal algorithm for sequential data compression' by J. Ziv et al, document D4 in the list of related documents.

The data compression unit 12 carries out a data compression step on the composite signal under the influence of the control signal supplied to its control input 19 and generates in response thereto a data compressed composite signal at its output 14.

The control signal generator unit 18 generates the control signal in response to the composite signal present at the output 8 of the merging unit 6. In the situation where the compression unit 12 is in the form of a Huffman encoder, the control signal at the input 19 is a statistical signal representing the probability of occurrence of samples having a specific amplitude. In the situation where the compression unit 12 is in the form of an arithmetic coder, the control signal in the same way is a statistical signal representing probabilities of occurrence of samples in the composite signal.

A comparison of the compression ratio obtained with the apparatus of FIG. 1 with the compression ratio obtained with separately data compression the two digital information signals, revealed that the apparatus of FIG. 1 had a 4% better performance.

Data compression can be carried out on a blockwise basis. Blocks of a plurality of the samples of the composite information signal can be data compressed by the data compression unit 12. Such blocks can be obtained such that they comprise a sample (L_i) of the first information signal first, followed by a sample (R_i) of the second information signal. Blocks can be preceded by a sync word. This enables a subsequent splitting of the composite signal into the separate information signals upon reception in a corresponding data expansion apparatus.

FIG. 2 shows another embodiment of the, compression apparatus in accordance with the invention. The compression apparatus of FIG. 2 shows a large resemblance with the apparatus of FIG. 1. The apparatus of FIG. 2 comprises all the elements already discussed with reference to FIG. 1, and further comprises a prediction unit 20, coupled between the merging unit 6 and the data compression unit 12. The prediction unit 20 comprise a predictor 22 and a signal combining unit 24, which is in the form of a subtractor. The predictor generates a prediction of the signal applied to its input and supplies the predicted version at its output. The signal combination unit 24 subtracts the original composite signal from the predicted version so as to obtain a residual signal, which is supplied to the output 26 of the prediction unit 20.

FIG. 2 shows in addition a further elaboration of the control signal generator unit 18', which comprises a series connection of the predictor 22 and a converter unit 21. The converter unit 21 generates the statistical signal, used as the control signal for the data compression unit 12, from the predictor output signal.

It should be noted here that the circuit construction of the predictor 22 and the signal combination unit 24 in the prediction unit 20 can be different from the circuit construction shown in FIG. 2. As an example, the predictor 22 could have been coupled in a feedback path from the output of the signal combination unit 24 to the second input of that same combination unit 24, see also FIG. 8. In such embodiment, the predictor 22 generates the predicted version of the signal applied to the first input of the combination unit 24 from the residual signal.

A merging unit of again another embodiment of the data compression apparatus is shown in FIG. 3. The merging unit 6' of FIG. 3 is capable of merging three information signal into a composite signal. In the present example, the three information signals are the left and right hand signal component of a stereo audio signal and a corresponding centre signal. The samples are merged into one datastream of the composite signal as follows:

$$L_0,R_0,C_0,L_1,R_1,C_1,L_2,R_2,C_2, \ldots$$

Other sequences could have been generated as well. Such as different orders, or each time merging eg. two samples of the same signal.

FIG. 4 shows an embodiment of a recording apparatus comprising the data compression apparatus shown in FIG. 1, which may include the prediction unit shown in FIG. 2. The recording apparatus further comprises a write unit 50 for writing data compressed composite signal in a track on the record carrier 52. In the present example, the record carrier 52 is a magnetic record carrier, so that the write unit 50 comprises at least one magnetic head 54 for writing the data compressed composite signal in the record carrier 52. The record carrier may however be an optical record carrier, such as a CD disk or a DVD disk.

FIG. 5 shows an embodiment of a transmitter for transmitting the data compressed composite signal via a transmission medium TRM, comprising the data compression apparatus as shown in FIG. 1, which again may include the prediction unit shown in FIG. 2. The transmitter further comprises a transmission unit **60** for applying the data compressed composite signal to the transmission medium TRM. The transmission unit **60** could comprise an antenna **62**.

Transmission via a transmission medium, such as a radio frequency link or a record carrier, generally requires an error correction encoding and a channel encoding carried out on the data compressed composite signal to be transmitted. FIG. 6 shows such signal processing steps carried out on the data compressed composite signal for the recording arrangement of FIG. 4. The recording arrangement of FIG. 6 therefore comprise an error correction encoder **56**, well known in the art, and a channel encoder **58**, also well known in the art.

FIG. 7 shows an embodiment of the data expansion apparatus in accordance with the invention, which is capable of reconverting the data compressed composite signal into replicas of the original left and right hand signal components of the stereo audio signal. The apparatus has an input terminal **70** for receiving the data compressed composite signal, as supplied by the data compression apparatus of FIG. 1. The input terminal **70** is coupled to an input **72** of a data expansion unit **74**, which has an output **76** coupled to an input **78** of a retrieval unit or means **80**. The retrieval unit **80** has two outputs **82** and **84**, coupled to a first and second output terminal **86** and **88** respectively.

The data expansion unit **74** has a control input **73** for receiving a control signal. The data expansion unit **74** is adapted to data expand the data compressed composite information signal in response to a control signal supplied to said control signal input **73**, so as to obtain a data expanded composite information signal at its output **76**. A control signal generation unit **75** is present, having an input coupled to the output **76** and an output coupled to the input **73** of the expansion unit **74**.

The apparatus of FIG. 7 receives the data compressed composite signal via its input **70**, which is supplied to the input **72** of the data expansion unit **74**. The data expansion unit **74** carries out a data expansion step on the data compressed composite signal, which data expansion step is the inverse of the data compressions step carried out by the data compression unit **12** of FIG. 1. As a result, a replica of the original composite signal will be generated and supplied to the output **76**. The replica of the composite signal is supplied to the retrieval unit **80**. The retrieval unit **80** splits the datastream applied to its input into two streams by supplying the odd numbered samples in the composite signal to the one output, eg. the output **82**, and the even numbered samples to the other output. As a result, replicas of the left and right hand signal components of the stereo audio signal appear at the terminals **86** and **88** respectively.

The control signal generator **75** generates said control signal in response to said data expanded composite information signal.

FIG. 8 shows another embodiment of the expansion apparatus in accordance with the invention. The expansion apparatus of FIG. 8 shows a large resemblance with the apparatus of FIG. 7. The apparatus of FIG. 8 comprises all the elements already discussed with reference to FIG. 7, and further comprises a prediction unlit **90**, coupled between the data expansion unit **74** and the retrieval unit **80** and a converter unit **77**. The prediction unit **90** comprise a predictor **92** and a signal combining unit **94**, which is in the form of an adder. The predictor **92** generates a prediction of the signal applied to its input and supplies the predicted version at its output. The signal combination unit **94** adds the replica of the original residual composite signal to the predicted version of the composite signal so as to obtain the replica of the composite signal, which is supplied to the output **96** of the prediction unit **90**.

FIG. 8 also shows a further elaboration of the control signal generator unit **75'**, which comprises a series connection of the predictor **92** and the converter unit **77**. The converter unit **77** generates the statistical signal, used as the control signal for the data expansion unit **74**, from the predictor output signal.

It should further be noted that the prediction unit **90** in the embodiment of FIG. 8 could have a circuit construction as shown in FIG. 2.

A retrieval unit of again another embodiment of the data expansion apparatus is shown in FIG. 9. The retrieval unit or means **80'** of FIG. 9 is capable of retrieving three information signals from the replica of the composite signal. In the present example, the three information signals are the left and right hand signal component of a stereo audio signal and a corresponding centre signal.

FIG. 10 shows the data expansion apparatus of FIG. 7 incorporated in a reproduction apparatus. The reproducing apparatus further comprises a read unit **100** for reading the data compressed composite signal from a track on the record carrier **52**. In the present example, the record carrier **52** is a magnetic record carrier, so that the read unit **100** comprises at least one magnetic head **102** for reading the data compressed composite signal from the record carrier **52**. The record carrier may however be an optical record carrier, such as a CD disk or a DVD disk.

FIG. 11 shows an embodiment of a receiver for receiving the data compressed composite signal via a transmission medium TRM, comprising the data expansion apparatus as shown in FIG. 7. The receiver further comprises a receiving unit **105** for receiving the data compressed composite signal from the transmission medium TRM. The receiving unit **105** could comprise an antenna **107**.

As has been explained above, transmission via a transmission medium, such as a radio frequency link or a record carrier, generally requires an error correction encoding and a channel encoding carried out on the residual signal to be transmitted, so that a corresponding channel decoding and error correction can be carried out upon reception. FIG. 12 shows the signal processing steps of channel decoding and error correction carried out on the received signal, received by the reading means **100** for the reproducing arrangement of FIG. 10. The reproducing arrangement of FIG. 12 therefore comprise a channel decoder **110**, well known in the art, and an error correction unit **112**, also well known in the art, so as to obtain a replica of the data compressed composite signal.

Whilst the invention has been described with reference to preferred embodiments thereof, it is to be understood that these are not limitative examples. Thus, various modifications may become apparent to those skilled in the art, without departing from the scope of the invention, as defined by the claims. Thus, as has been said above, it is possible to combine more than two information signals into a composite signal in order to realize data compression.

Further, the invention lies in each and every novel feature or combination of features.